Corrosion Inhibitors for Mild –Carbon Steel in 0.1M H_2SO_4 Acid using Cashew Extract

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Abstract— **There are several ways of tackling the issue of corrosion in the industry and one of such ways is the use of inhibitors which is eco-friendly. The aim of this study is to produce corrosion inhibitor via cashew waste extracts. Mild carbon steel with thickness 0.1 cm was used. It was cut into coupons of dimensions 4 x 5 x 0.1 cm. The cashew waste extract produced was used as a corrosion inhibitor on mild carbon steel in 0.1M tetraoxosulphate (vi) acid. It was observed that as the concentration of inhibitor increases, the inhibitor efficiency also increases. The optimal efficiency was observed at 87.3%. Surface morphology result showed that the presence of cashew extract on the mild- carbon steel formed a passive layer on the surface. It was concluded that cashew waste was an efficient corrosion inhibitor.**

Index Terms—**Corrosion, Inhibitor, Mild Carbon steel, Tetra-oxo-sulphate (vi) acid**.

I. INTRODUCTION

Corrosion is the gradual deterioration of a material by electrochemical reaction due to its interaction with its environment. It has been an everyday challenge in all sectors of the economy particularly the manufacturing industry (El-Etre, 2003). It is an irreversible interfacial reaction of a material (metal, ceramic, polymer) with its environment which results in consumption of the material or in dissolution into the material of a component of the environment. Corrosion is affected by multiple variables, including the nature of the alloy, quality of the water, formulation, mixed metals and chemical species competing for the surface. Many structural alloys corrode merely from exposure to moisture in air, but the process can be strongly affected by exposure to certain substances. Carbon steel is one of the most important alloys being used in a wide range of industrial applications. There are several ways of tackling the issue of corrosion in the industry and one of such ways is the use of inhibitors which is eco-friendly. According to Rocha *et al.* (2012), it was reported that there are a number of organic and inorganic compounds which can inhibit corrosion of steel.Naturally occurring molecules exhibiting a strong affinity for metal surfaces are the focus of research oriented toward the development of environmentally friendly corrosion inhibitors; compounds showing good inhibition efficiency and low environmental risk. Many researchers have done some works on green corrosion using grape pomace apricot juice and *Spirulina platensis* (Rocha *et al.*2012; Okafor *et al.*2011, Aboia and James, 2011). Inhibitors protect metals by effectively adsorbing its surface and blocking the actives sites for metal dissolution and/ hydrogen evolution, hereby hindering overall metal corrosion in aggressive environments (Nnanna et al. 2011). Many studies had been carried out to find suitable compounds useful as corrosion inhibitors for this metal in different aqueous solutions. (Rajendra, et al.2005).
Eddy *et al*. (2009) stated that among the so-called ‘‘green corrosion inhibitors” are organic compounds that act by adsorption on the metal surface, such as ascorbic acid, succinic acid, tryptamine , caffeine and extracts of natural substances. The efficiency of these organic corrosion inhibitors is related to the presence of polar functional groups with S, O or N atoms in the molecule, heterocyclic compounds and pi electrons. The polar function is usually regarded as the reaction center for the establishment of the adsorption process. Studies have been conducted on natural extracts that can significantly replace synthetic compounds. One of these natural compounds is fruits (Antonijevic*, et al.*2008).Fruit is a rich source of chemicals such as vitamins, minerals, and phenolic compounds. According to Rocha *et al* (2012), banana peel, fruit peel (mango, orange and passion fruit), coffee grounds, papaya seed, seeds and peels from papaya and garlic produced inhibitors. The use of industrial wastes as corrosion inhibitors is indeed welcoming and very appealing. This study investigate the use cashew waste as an eco-friendly inhibitor for carbon steel in Nigeria.
Corrosion prevention can take a number of forms depending on the circumstances of the metal being corroded. Corrosion prevention techniques can be generally classified into 6 groups: These are: Environmental Modifications; Metal Selection and Surface Conditions; Cathodic Protection; Corrosion Inhibitors; Coating, and Plating

II. MATERIALS AND METHOD

Material

i.Waste fruits of cashew (*Anacardium occidentale L.*) were collected .
ii. Mild Carbon Steel bar

Chemicals.

All the chemical and reagent used in this work were of analytical grade of sigma chemical company UK. They include: Sulphuric Acid; Acetone and Ethanol

Methodology

Preparation of samples

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The samples prepared here is the corrosion medium for the mild steel bar needed in calculating the weight loss of the material. The electrolyte 0.1 $molL^{-1}$ was solution prepared using double-distilled water. The experiment was carried out under non-stirred and naturally aerated conditions.

Preparation of plant extract

The 2kg of waste cashew fruits were sun dried. After sun drying them .the cashew nut was separated from the dried waste fruits; after which the dried waste fruit was pulverized. 150g of the ground dried waste cashew powder was weighed and soaked in 250 ml of ethanol for 24 hours, and then filtered and concentrated using rotary evaporator and water bath. The resulting extract was in semi-solid form.

Preparation of Specimen

Carbon steel strips (BDH grade) containing (weight %): C 0.2, P 0.024, Si 0.003, Mn 0.35, and rest Fe were used in this research. Coupons cut with 4 x 5 x 0.1 cm dimensions were used for weight loss measurements. 10 mild steel bars of this dimension where cut and where used for this test. These coupons were cleaned by distilled water and ethanol. These coupons were further treated using emery paper. Then washed using distilled water and degreased with acetone and were stored in the desiccator.

Weight Loss Measurements

Weight loss measurements was conducted under total immersion using 250 ml capacity beakers containing 20-100% test solution at 30-33°C maintained in the laboratory (room temperature). The carbon steel coupons were weighed and suspended in the beaker with the help of rod and hook.

Procedure

The mild carbon steel specimens was immersed in 100 mL of 0.1M H_2SO_4 containing various concentrations of the inhibitor (20%, 40%, 60%, 80%) in the presence and absence of the corrosion inhibitor for 336 hours. First, there was control experiment for H_2SO_4.

Then various percentages of the inhibitor were added to the other beakers containing the various test samples. The specimens were totally immersed in all ten (10) test solutions and were left for 336 hours during which readings were carried out at intervals of 48 hours. A total of 7 readings were carried out and the results penned down accordingly. The weight of the specimens before and after immersion was determined after every 48 hours using weighing balance. The corrosion products were cleansed with distilled water, dried and then weighed to determine its weight. The in-hibition efficiency (IE) was calculated using the following equation:

{W2-W1}/W1 X 100%...1

Where W_1 is the corrosion rate in the absence of the inhibitor, and W_2 is the corrosion rate in the presence of the inhibitor.

Surface Examination

For morphological study, surface features (2.0 cm x 2.0 cm x 0.15 cm) of carbon steel were examined before and after exposure to 0.1M H_2SO_4 solutions for 336 hour with and without inhibitor. Scanning electron microscope was used for this investigation. Also FT-IR was used in examining the control experiment of H_2SO_4 and that of the optimum corrosion inhibitor in both acids.

RESULTS AND DISUCUSSION

Weight Loss Method

The corrosion of mild steel in 0.1M H_2SO_4 solution containing various concentrations of inhibitor at room temperature was studied by weight loss measurements. The corrosion rate of mild steel was determined via the below formula:

W=Δm/S×t...2

Where Δm is the mass loss (g)

S= $20cm^2$= $0.002m^2$[the area (cm^2)]

t= 48hours [immersion period (hours)]

The percentage inhibition efficiency [IE%] was calculated using the relationship in Eqn. 1

Where W_1 is the corrosion rate in the absence of the inhibitor, and $_2$ is the corrosion rate in the presence of the inhibitor.

Table 4.1:.Corrosion rates data of mild steel in 0.1M H_2SO_4 in absence and presence of different concentrations of cashew inhibitor.

Inhibition concentration (%)	Corrosion rates ($g/m^2.hr$)	θ	IE (%)
0	1.04		
20	0.69	0.337	33.7%
40	0.52	0.5	50%
60	0.35	0.663	66.3%
80	0.17	0.837	83.7%

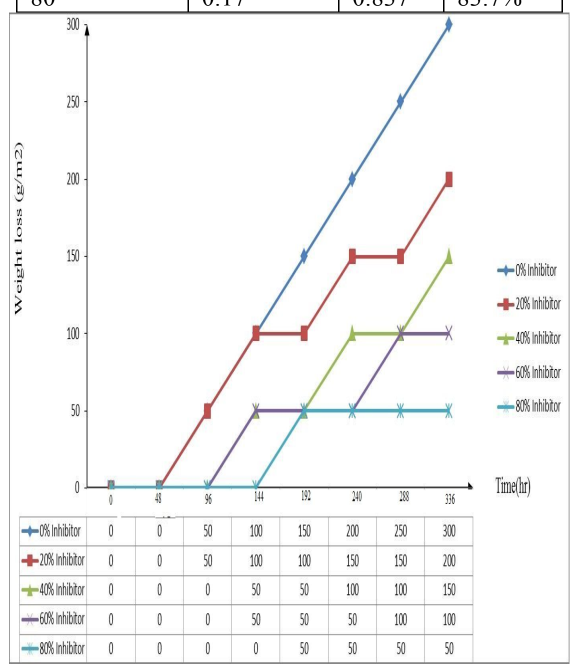


Figure 1: Weight loss-time curves of carbon steel in 0.1M H_2SO_4 in the absence and presence of different concentrations of Cashew inhibitor.

Surface Morphology

FT-IR was used to evaluate the nature of the film formed on the surface of the metal. After the concentration of the inhibitor with the highest Inhibition Efficiency (IE %) was discovered, the samples were sent to the laboratory for analysis. Figure 2 showed the analysis done on the metal with 0% inhibition concentration and that of 80% inhibition concentration in and 0.1M H_2SO_4.

The strong band at approximately 3450cm^{-1} can be associated with O–H stretching of the phenolic group. The band at 2928 cm^{-1} is related to C–H stretching vibration. The strong band at 1630 cm^{-1} is assigned to conjugated C=O stretching vibration. The band at 1552 cm^{-1} can be attributed to C=C-C aromatic ring stretching. The bands between 1467 and 1431 cm^{-1} can be attributed to angular deformations of C-O-H in phenols. The band at approximately 1321 cm -1 is attributed to C-O stretching from the pyran-derived ring structure present in the flavonoids. The bands at 1083 and 1151cm^{-1} can be assigned to C-H deformations of the aromatic ring. This result indicates that cashew extract contain flavonoids in their composition, which can act as corrosion inhibitors. The FT-IR spectra for figure 3 is almost the same, so it can be concluded that the extracts have the same composition, and differ mainly on their concentration.

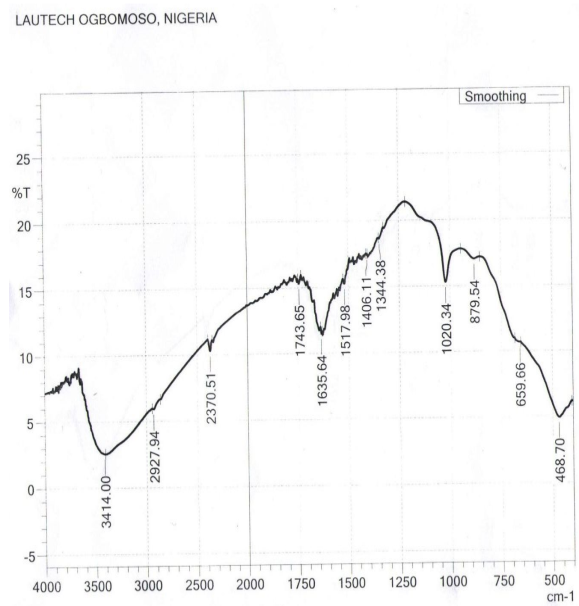


Figure 2: FT-IR spectra of coupon with 0% inhibition concentration in 0.1M H_2SO_4

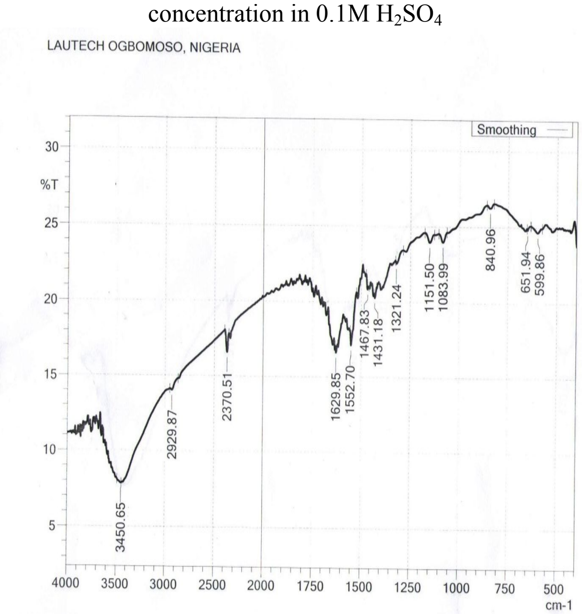
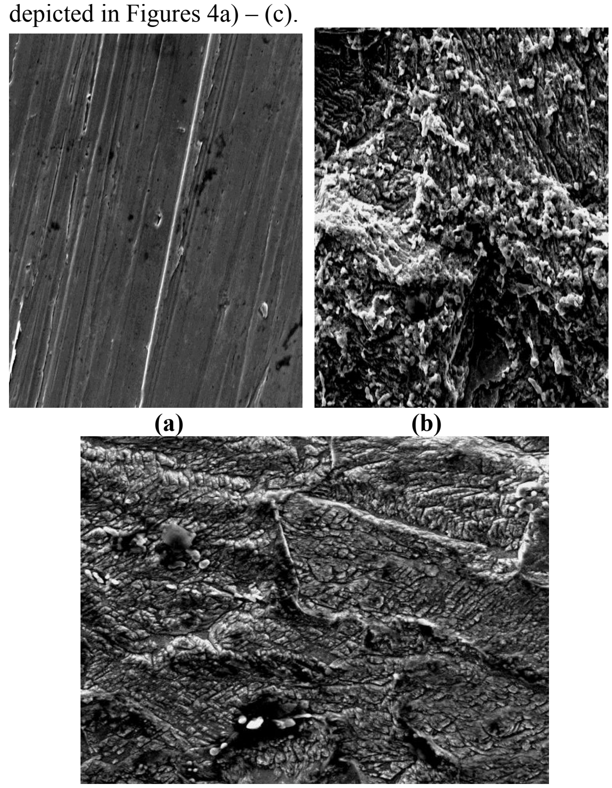


Figure 3: FT-IR spectra of coupon with 80% inhibition concentration in 0.1M H_2SO_4

Scanning Electron Microscopy (SEM)

Surface morphology of polished mild steel, mild steel immersed in 0.1M H_2SO_4, and mild steel immersed in 0.1M H_2SO_4 with 80% corrosion inhibitor were recorded and depicted in Figures 4a) – (c).



(a) **(b)** **(c)**

Figure 4: SEM micrographs of mild carbon steel surface (a) before immersion (b) total immersion in H_2SO_4 (c) immersion in 0.1M H_2SO_4 with 80% inhibition concentration.

From the above, it was observed that the inhibition concentration of 80% for 0.1M H_2SO_4 gave the highest inhibition efficiency at 83.7% respectively., the graphs clearly showed that weight loss reduced as more concentrations of the corrosion inhibitor was added. Within the test hours of 336 hours, there was a 250g/m^2 of weight loss in 0.1M H_2SO_4 with 0% inhibition concentration, while there was just a 50g/m^2 of weight loss in 0.1M H_2SO_4. The inhibition efficiency is directly proportional to the concentration of the inhibitor (i.e. inhibition efficiency increases with increased inhibition concentration). It was observed from the FT-IR result that the cashew extract contain flavonoids in their composition, which can act as corrosion inhibitors. The inhibitor (in concentrations of 20%, 40%, 60% and 80% respectively) was added to the media while the coupons (mild carbon steel) were totally immersed in it. The result showed that at 80% concentration of the inhibitor, optimal efficiency of 83.7% was observed in 0.1 M H_2SO_4. Moreover, the FT-IR spectra of the metal also showed a high degree of correlation with each other. Surface morphology showed increase of a passive layer of protection area with increase of concentration of the inhibitor.

CONCLUSION

It was concluded that cashew waste fruit was a very good eco-friendly corrosion inhibitor for mild carbon steel. It was observed that, as the concentration of the inhibitor increases, the corrosion rate decreases and the inhibitor had an optimum efficiency of 83.7%. The result obtained from the FT-IR spectra showed flavonoids which are the active corrosion inhibiting agents in the cashew. SEM analysis showed a passive layer against the corrosive ions on the surface of the mild steel in H_2SO_4 .

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